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Indian Standard

PACKAGING CODE

PART 3 ANCILLIARY MATERIALS

Section 1 Cushioning Materials

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INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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Indian Standard

PACKAGING CODE

PART 3 ANCILLIARY MATERIALS

Section 1 Cushioning Materials

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Indian Standard

PACKAGING CODE

PART 3 ANCILLIARY MATERIALS

Section 1 Cushioning Materials

0. FOREWORD

0.1 This Indian Standard (Part 3/Sec 1) was adopted by the Indian Standards Institution on 29 February 1984, after the draft finalized by the Packaging Code Sectional Committee had been approved by the Marine, Cargo Movement and Packaging Division Council.

0.2 The packaging code is being issued in the following parts which have one or more sections:

Part 1 Product Packaging
Part 2 Packaging Materials
Part 3 Ancilliary Materials
Part 4 Packages
Part 5 Packaging Operations
Part 6 Storage & Transportation
Part 7 Packaging Machinery
Part 8 Testing

This section of packaging code (Part 3/Sec 1) deals with cushioning materials.

0.3 During transportation and handling a product is liable to damage from impact shock or vibration as they are transmitted to the contents of the package. It is, therefore, desired to reduce the shock by giving protection, to the product, within the container, by the use of special materials or devices which will absorb whole or part of the impact shock or vibration. Cushioning is therefore that part of packaging which protects an article from damage due to shock or vibration. However, it is the impact from drops and not vibrations which generally determine the design of cushioning.

0.4 The principal methods of protecting from shock are by their distribution, by absorption and by localization. Cushioning materials reduce the levels of shocks by allowing controlled movement of the packaged article within the container at the instance of impact, thereby reducing the deceleration and resultant force transmitted to the article.

0.5 Various types of cushioning materials are available, which vary in the way they deform and also in their ability to recover from such deformation. The functions, classification, properties and selection of the cushioning materials as well as the methods of test for the same are described in the code.

0.6 In the preparation of this standard considerable assistance has been derived from BS 1133 : Section 12 : 1967 'Packaging code: Cushioning materials (excluding packaging felt)', issued by the British Standards Institution.

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1. SCOPE

1.1 This Indian Standard (Part 3/Sec 1) gives the functions, classification, properties and lays down the guidelines for the selection of cushioning materials for different uses. The methods of tests for cushioning materials are also briefly described.

2. FUNCTIONS OF CUSHIONING MATERIALS

2.1 Cushioning materials are used for a number of purposes. The selection is determined by the functions to be performed (*see* **2.1.1** to **2.1.6**).

2.1.1 Protection of delicate and fragile articles against the effects of shock caused by rough handling such as dropping the container and against shocks and vibrations encountered during transportation.

2.1.1.1 The article shall be protected against forces from any direction, since containers may be dropped or placed on any face. As a rule fragile product or interior containers containing fragile products shall be completely surrounded by cushioning and in effect " floated " in the cushioning material. Semi-fragile products usually require cushioning to be used only to supplement protective blocking or bracing. Most often cushioning is used to prevent the semi-fragile products from making direct contact with rigid blocking, bracing or surfaces of the container. Sufficient cushioning shall be used to diminish shocks which may be transmitted through the blocking to the article.

2.1.2 Protection of delicate and highly finished surfaces against abrasion.

2.1.2.1 Surfaces of product which may be damaged by wood blocking, strapping, container surfaces, or by other articles in a container are protected by cushioning. The use of cushioning for this purpose differs from blocking and shock protection applications in that lesser amounts and thicknesses of material are required. The materials used need not ordinarily be thicker than is necessary for the material to retain its original position in the pack without disintegration by possible independent movement of the article and the container. Paper backed materials are often used for surface protection.

2.1.3 Protection of small projections on articles.

2.1.3.1 Many articles which may or may not require cushioning for shock protection may require cushion blocking. The use of cushioning to block small or irregular shaped articles as known as cushion blocking. This often saves time and materials which would otherwise be spent in preparing an elaborate system of rigid blocking. It is particularly expedient to use cushioning as blocking if cushioning is also required for shock protection purposes. Although cushion blocking is not extensively used for semi-fragile or rugged articles, these articles may be cushion blocked if they are small in size or irregular in shape. When a number of rugged of semi-fragile articles or components or small articles are packed in a container cushion block is often used. Cushioning should not be employed to block heavy or large articles.

2.1.4 Protection of moisture, grease or water proof carriers at points of contact with sharp edges of the articles itself, packing material or container to prevent rupture or severe abrasion of the barriers.

2.1.4.1 This requirement for cushioning pertains to the protection of packaging materials such as moisture vapourproof barriers. Objects of any size or degree of fragility may have sharp corners or projections which could puncture the barriers or even the container. These projections must be covered so that the cushioning material rather than the sharp edges of the object are in contact with the barriers or other wrappings.

2.1.5 Filling of voids in the container.

2.1.6 Other secondary purposes, if any, which the cushioning is required to fulfil in addition to its primary purpose—for example, fragile glass bottles containing liquids should be packed in a liquid absorbent cushioning material. Thus, in case of breakage, the liquid would be absorbed by the cushioning and would not run freely. The primary use of cushioning in this case would be to absorb shocks and prevent damage; the secondary use would be to absorb the liquid if the glass containers were damaged.

3. SELECTION OF CUSHIONING MATERIALS

3.1 A good cushioning material shall be resilient and shall have durable impact qualities, retaining its cushioning properties without deterioration after repeated shocks and rough handling. Generally, shock protection requirements shall be given first consideration, other primary or secondary uses can then be considered. The shock absorbing capacity shall not change appreciably with changes in moisture content. Choice should be made on the basis of:

a) resistance of the article against damage by shock;

b) mass of the article to be cushioned on bearing surface;

c) shape of the surface to be cushioned;

d) hazard levels resulting from handling, storage transport system and its period, environmental conditions, transhipment, etc;

e) period of time over which the shock is completed;

f) shock absorbing capacity of the cushioning materials, including the effect of moisture thereon; and

g) susceptibility of the metal article to corrosion due to moisture absorbed by hygroscopic properties of the cushioning material.

When too much mass is concentrated on a cushioning material, it compresses to such a degree that it does not absorb the impact or shock energy, which is therefore largely transmitted to the article. The thickness of cushioning material should also be sufficient to allow for compacting under the weight of the article. Delicate items which are very susceptible to damage through rough handling, usually require the use of several inches of low density, highly resilient cushioning materials. Cushioning materials for heavy mass items shall be dense and firm.

4. PROPERTIES OF CUSHIONED MATERIALS

4.1 The properties required of a cushioning material depend on the nature of article to be protected. The important characteristic properties to be considered while selecting are given below. A comparative chart of properties of cushioning materials is given in Appendix A.

4.1.1 *Resilience* — Resilience is the ability of the cushioning material to undergo deformation on application of a load and the ability to recover rapidly and almost completely on removing the load.

4.1.2 *Compression Set* — Compression set is the permanent deformation of the material due to either the static load on the system or to repeated transit compression. In mathematics, compression set can be defined as the difference between the original thickness of the cushioning material and the thickness of the same material after having been released from

compression under a standard load for a given period of time, expressed as a percentage of original thickness. Cushioning materials having high compression set creates free moving space in the container.

4.1.3 *Rate of Recovery* — The time taken by the cushioning material to return to its original shape after compression is known as rate of recovery. Some materials have a rapid rate of recovery, due to the springback action. This may result in damage to the product. At the same time, it should not take too long a period for the cushioning material to come back to its original shape.

4.1.4 *Cushion Factor* — It can be defined as the ratio of the maximum stress to the total energy absorbed/unit volume of the material. Cushioning materials having lower cushioning factors require less volume.

4.1.5 *Creep* — Creep can be defined as the gradual deformation of a cushioning material taking place over a period of time.

4.1.6 *Damping* — Damping is the periodic oscillations of a material before it comes to rest. A resilient cushioning material after being compressed and during its recovery should come to its original shape without any oscillations.

4.1.7 *Corrosion* — The corrosive effect of some cushioning materials is undesirable when packaging items with critical surfaces. When this cannot be avoided, item shall be shielded from such materials by a neutral wrap or liner. Cushioning materials with a high acidic or basic content must be enclosed within water-proof or water vapour proof barriers. The corrosive nature of the cushioning materials is normally measured by the hydrogen/ion concentration-*p*H.

4.1.8 *Hygroscopicity* — Hygroscopic cushioning materials will have less cushioning value or cushioning factor at high moisture content than at lower moisture content. For this reason when such materials are used they must be protected against long exposure to high humidities by a sealed waterproof barrier. When this is not possible the use of non-hygroscopic materials which respond less rapidly to moisture change, should be used. Most materials when wet will cause corrosion of contacting metal surfaces. In such instances grease-proof or water vapour barriers are recommended between cushioning materials and the product.

4.1.9 *Micro-Biological Properties* — Fungus resistance of some materials is low and allows the growth of mould, mildew and other fungi. Many materials can be treated to inhibit such growth. However, such treated materials are often very corrosive to metal surfaces and must be isolated from them.

4.1.10 *Dusting* — This often results from the disintegration of the bonded fibre structure materials and these detached particles can work into services and critical working parts of the product.

4.1.11 *Abrasive Characteristics* — The abrasive characteristics of some materials are factors which must be considered when protecting precision surfaces such as the lenses of optical instrument. Some cushioning materials are soft-textured and generally can be placed in contact with easily marred surfaces. Coarse textile material should not be used on such surfaces.

4.1.12 *Performance at Low Temperatures* — Low temperature performance of certain cushioning material makes them suitable for use in high altitude transport in shipments to cold regions because they remain relatively soft and resilient.

4.1.13 *Density* — Density is another important property of a cushioning material, which limits its usage due to its weight contributing to the tare mass of a package and naturally increasing the cost of transport. Although some materials have a relationship between the density and its cushioning factor, the correlation between them is not generally applicable.

4.1.14 *Other Characteristics* — Other properties which should be considered in choosing the cushioning materials are fibre resistance or flammability and the possibility of the material causing health hazards to the personnel during application dynamic performance and effect of repeated impact load bearing capacity. Liquid absorbing capacity may be required for cushioning bottles with liquid products.

5. CUSHIONING AND CUSHION DESIGN

5.1 Cushioning

5.1.1 *Simplified Cushion Theory* — Any falling article moves towards the ground with a constant acceleration due to the force of gravity. To bring the article to rest within a distance less than the height from which it has fallen requires a correspondingly higher negative acceleration (that is, 'deceleration'). This deceleration is approximately proportional to the ratio of the drop height to the stopping distance, that is, the distance through which the velocity of impact is reduced to zero. A suitable cushioning material, placed between the article and its container, ensures that sufficient space is available for the article to be brought to rest and at the same time provides the decelerating force.

Unlike the accelerating force, the decelerating force is not constant but increases continuously from zero at the instant of impact, to a maximum value at the instant when the article is finally brought to rest. It is convenient to express the magnitude of this deceleration in terms of the gravitational unit (g) and this is the general practice.

The maximum deceleration which may be applied to a given article without damaging it is known as the fragility factor of the article and is expressed in multiples of g. For example, an article with a fragility factor of 50 will withstand without damage a deceleration of 50 times that due to gravity. The fragility factor of an article shall be known or assessed before a cushion can be designed for it. The drop height from which it is required to protect the equipment be specified also (*see* Fig. 1) before cushion design can begin.

The thickness of a cushion which exerts a constant reaction force as it is compressed and is compressible down to zero thickness is given by the simple expression:

$$t = \frac{h}{G}$$

where

t = thickness,

h = height of drop, and

G = deceleration in g units.

This behaviour is not realized with cushion materials, which are deficient on two counts: the reaction force starts at zero and increases to a maximum value in a manner peculiar to the type of material, and secondly, the compressed material occupies a finite thickness.

To compensate for these deficiencies the actual thickness of any material will need to be greater than that given in the above formula to provide the required (maximum) deceleration and energy absorption. The thickness formula is modified by a multiplying factor which is called the cushion factor. Thus:

$$t = \frac{ch}{G} \qquad c = \text{cushion factor} \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

It is important to note that this factor is not a fixed quantity but varies according to the conditions of dynamic stress and strain present in the material. It can be shown, however, that there exists a minimum value for cushion factor under optimum circumstances of use of any material. This optimum value is not independent of drop height or material thickness, but will vary with these parameters to a small extent, dependent upon the type of material.

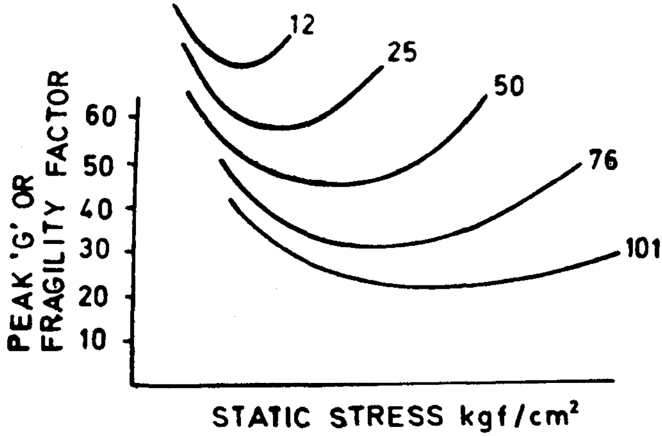

FIG. 1 PEAK DECELERATION-STATIC LOAD CURVES FOR ONE DROP HEIGHT AND A RANGE OF CUSHION THICKNESS

5.2 Cushion Design

5.2.1 *Cushion Factor Method* — Figure 2 shows the cushion factor plotted against dynamic stress. Curves as given in Fig. 2 can be obtained by dropping loads of different magnitudes on to the material from a given drop height and measuring the peak decelerations occurring. The value of cushion factor (c) at each point can be determined by the following Formula 1:

Formula 1

$$t = \frac{ch}{G}$$

where

t = thickness of cushion,

h = height of drop,

G = decleration in g units, and

c = cushion factor.

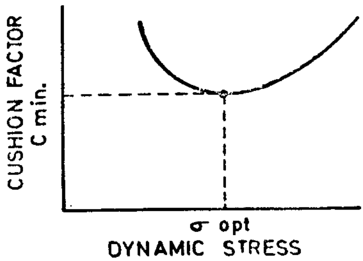

FIG. 2 CUSHION FACTOR PLOTTED AGAINST DYNAMIC STRESS

The value of dynamic stress σd under each loading condition is calculated from the expression using Formula 2.

$$\sigma d = \frac{WG}{A}$$

where

W = mass of cargo,

G = measured deceleration peak value in g units, and

A = area of cushion.

This procedure should be repeated for all thicknesses of material and drop heights of interest. The basic shock absorbing qualities of a cushion material can thus be illustrated as minimum cushion factor and dynamic stress (optimum). These properties can be used as a basis for comparison of materials. For example, the smaller the cushion factor, the smaller the thickness of material needed for any given protection requirement. Similarly, the higher the dynamic stress value, the smaller will be the area of material needed (*see* Fig. 3 and 4).

t is the uncompressed cushion thickness,

h is the height through which the outer container falls, and

d is the maximum compression.

Thickness is calculated by inserting values for drop height (known), maximum permitted deceleration in g units (fragility factor) and minimum cushion factor (from appropriate curve) in Formula 1. When a calculated thickness falls between two standard thicknesses of sheet material, the greater thickness be used to prevent the peak deceleration exceeding the fragility factor of the article. An increased protection will, therefore, be afforded in practice, that is, the peak deceleration will be lower and this value, calculated from the thickness formula, shall be used in the dynamic stress formula to obtain the area required. Area is

calculated by transposition of Formula 2 and by inserting values for mass of cargo (known), peak deceleration and optimum dynamic stress (from curve).

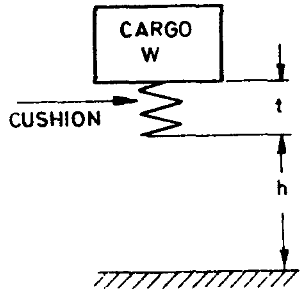

FIG. 3 POSITION OF CARGO BEFORE DROPPING

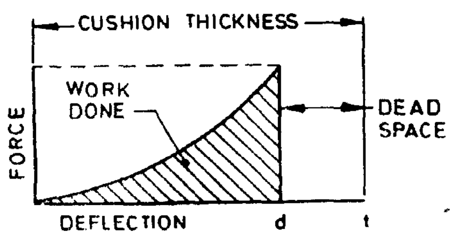

FIG. 4 FORCE DEFLECTION FOR A CUSHION DURING IMPACT

5.3 Peak Deceleration/Static Stress Method — An alternative and useful way of illustrating the data obtained by drop tests on a material is shown in Fig. 1, where peak deceleration is plotted against static stress for several thicknesses of material. The static stress on the cushion is $\frac{\text{mass of cargo}}{\text{area of cushion}}$. The curves shown in Fig. 1 are applicable to one height of drop. A separate set is required for each drop height of interest.

This method of presenting dynamic performance data displays the three basic design parameters, namely:

a) the fragility factor of the item,
b) the drop height, and
c) the static stress,

and enables the designer to select the thickness and area of cushion required. This is done for an item of fragility *G* as follows:

From the peak deceleration static stress curves for the appropriate drop height the minimum cushion thickness is found, which gives a deceleration equal to or less than *G* (*see* Fig. 5).

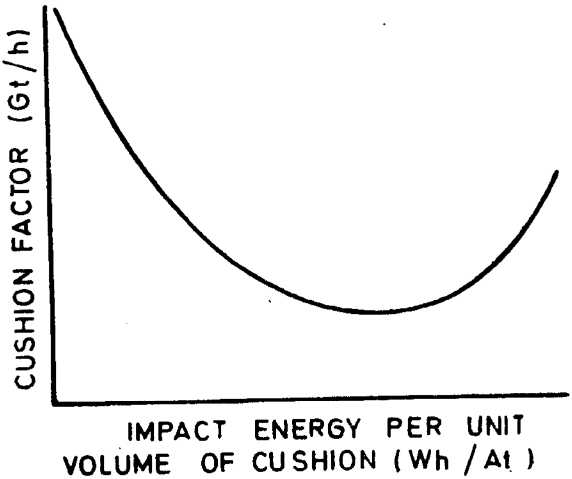

FIG. 5 CUSHION FACTOR CURVE CORRESPONDING TO FIG. 2

The minimum and maximum static stresses which can be used for this thickness are also determined, and the area of cushion shall lie between:

$$\frac{\text{mass of item}}{\text{minimum static stress}} \text{ and } \frac{\text{mass of item}}{\text{maximum static stress}}$$

If the areas so found are larger than the face of the article, the material is too compliant for this application, and either a greater thickness shall be used or a stiffer material chosen.

If the cushion area required is very much smaller than that of the face, considerable care is required to dispose the cushioning material in such a way that it fulfils its secondary function of positioning the article in its container. This can be achieved by dividing the required area into strips or blocks which are placed near the edges or corners of the cargo provided that they do not buckle, or cut-outs can be used to reduce the area. Alternatively, more compliant material may be used.

6. CLASSIFICATION OF CUSHIONING MATERIALS

6.0 Cushioning materials can be broadly classified into the following three categories based on their use and properties:

a) Space fillers,

b) Resilient cushioning materials, and

c) Non-resilient and rigid cushioning materials.

6.1 Space Fillers — Space fillers are mainly used to fill the voids in packages as dunnage to prevent reorientation of the items and sometimes to absorb liquid products spilled from the broken unit containers.

6.1.1 *Granulated Materials*

6.1.1.1 *Ground cork* — Cork is made from the outer bark of the holm oak. Holm oak is an evergreen species *Overcus suber* which grown mainly in Spain. It is tough, light and elastic. Because of these properties it is mainly used as space filling cushioning material.

6.1.1.2 *Saw dust and coir pith* — These are cellulosic materials and are cellular in structure and granular in form.

6.1.1.3 *Kieselguhr* — This is a fine white siliceous powder containing the remains of algae, used as a space filler, particularly around tins of liquids chemicals as it is non-inflammable and inert and will readily absorb most liquids.

6.1.2 *Fibres and Strips in Bulk Form*

6.1.2.1 *Paddy straw and dry grass* — Straw and hay are cheap loose cushioning materials used to fill voids. They absorb water and are corrosive in nature. They are abrasive and have high dusting characteristics. A disadvantage of these material is that on becoming wet they lose their cushioning property and provide good medium for the growth of fungi and bacteria.

6.1.2.2 *Wood wool* — This material consists of thin pliable narrow shavings of wood. It provides a loose cushioning suitable for nesting individual stores or interposing between and around a number of stores where its moisture retaining and other contaminating properties are tolerable e.g. in the packaging of crockery and glassware. As wood wool absorbs water, it should be used inside a waterproof barrier. A disadvantage in the use of this material as that it tends to break into dust when handled repeatedly. Wood wool pads may be used when its direct contact with the stores packed is not desirable. For more details *see* IS : 1707-1979*.

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*Specification for wood wool for general packaging purposes (*first revision*).

6.1.2.3 *Paper shavings* — Paper shavings known as paper wool are cheap general purpose cushioning materials and provide good protection to light weight bulky and delicate articles e.g. electric bulb, confectionery and biscuits. They are used for:

a) mitigating shock,

b) protecting surfaces from abrasion, and

c) positioning an article in a container and preventing reorientation of the object.

These are moisture absorbent and should be used inside water-proof barriers, due acidic nature corrodible to metallic surface. Paper cuttings, are manufactured from any variety of papers excluding newsprint. The length of at least 50 percent of the cuttings shall be 25 cm or above. Amount of cuttings less than 12 cm in length shall be less than 5 percent. The width of the cutting shall be between 3 and 10 mm. The thickness of the cutting shall not be more than 0·12 mm. The limit of moisture content is 10 percent. For more details *see* IS : 4356-1967*.

6.1.2.4 *Creped cellulose wadding* — Creped cellulose wadding is used in packaging to perform:

a) *Surface protection* — The soft open tissues of cellulose wadding prevents scratching and etching of fine surfaces by absorbing microscopic dust particles into the open pores of the wadding.

b) *Cushioning* — Because of its good resilience, light weight and low cost creped cellulose wadding is used as a cushioning material to protect delicate products from shock.

c) *Dunnage* — Creped cellulose wadding is used primarily to brace and cushion irregular shaped objects to prevent them from moving during shipment. Creped cellulose waddings is generally supplied in the following two grades:

   1) Water absorbent grade, and

   2) Water resistant grade.

Water resistant grade will absorb 16 to 12 times water in mass. Water resistant wadding is normally used in cases where a non-hygroscopic material is needed. Wadding treated with water-resistant resin is designed to absorb less than three times its mass of water.

6.1.2.5 *Extruded or shredded foam plastics* — These are normally made from expanded polystyrene and have very low density, good resilience and low compression set and good water resistance and no dusting. They are non-corrosive and fungus resistant, but are very expensive.

*Specification for paper cutting.

6.1.2.6 *Corrugated fibreboard* — Single face corrugated board which performs a combined and cushioning function has broadest commercial application. The wrappability is increased by pre-scoring the sheet in a criss-cross or other pattern. Most applications of single face corrugated fibre board are for odd shaped sizes and packaging is generally, manually and individually performed from either a roll or pre-cut sheets.

6.2 Resilient Cushioning Materials — Resilient cushioning materials are used to protect packed items from damage due to repeated shocks. Materials falling in this group have good compressibility and shall be able to return to their original condition after each shock. They should be able to absorb shock energy without exerting too much force on the item.

6.2.1 *Bonded Fibre Materials*

6.2.1.1 *Latex (rubberised hair)* — This material is manufactured from animal fibres usually consisting of about 80 percent horse hair and 20 percent horsemane, horse tail or cow tail, bonded with rubber latex. This is available in flat sheet and mountings. To give greater flexibility and a wider range of static loadings the following three systems have been developed:

a) *Atlas modules* — A large number of small modules are formed together on this sheet of high density rubberized hair, thus any number of modules can be cut from the sheet to suit a particular need. Corner blocks and conforming moulds can also be constructed by suitable cuttings.

b) *Oriented rubberised hair* — Most of the hair in a sheet lie in the plane of the sheet. By cutting the sheet into strips and rotating the strips through 90° then resticking them, the hair lies at right angles to the plan of the sheet. This process changes the load/deflection characteristics from cubic for the flat sheet to anemalous for the oriented sheet. This also has the effect of reducing the cushion factor from about 4·5 to about 2·5.

c) *Crimped rubberised hair* — Here the orientation is done on a machine and is performed by combining a uniform layer of curled hair and latex into a thicker sheet of greater density before curing the latex. By this method the layer of the hair is controlled at an angle to the plane of sheet.

6.2.1.2 *Rubberised coir* — This material consists of vegetable fibres bonded with latex and is available in sheet or mouldings in a range of densities. It is neutral and is less corrosive. In addition it has low moisture content and low water absorption, low dusting and can be treated with fungus-resistant chemicals. As a cushioning media it has

good resilience, low compression set, fair damping and load/deflection characteristic tangent type. This material is widely used for providing cushioning to light engineering goods such as typewriters, calculators, etc, and also for fragile equipments such as radios and sophisticated electronic equipments.

6.2.2 *Polyurethane Foams* — This is formed by polymerization and simultaneous expansion of an isocyanate and hydroxyl compound. Available in sheets or moulding and in a range of densities from 24 to 96 kg/m^3. There are two general types of flexible polyurethane foam:

a) based on polyester, and

b) based on polythene.

6.2.3 *Expanded Polyethylene* — This is a non-intercommunicating cellular material formed by expanding ethylene polymers by various methods. Expanded polyethylene is flexible and useful cushioning material. It is resistant to common acids, alkalis and solvents and slightly attacked by concentrated nitric acid.

6.2.4 *Expanded Polystyrene (Flexible)* — This material is formed by the polymerization of styrene beads which are subsequently expanded by a carefully steam heating process. The final expansion of the styrene usually takes place in a mould contoured to the required shape. Slabs are made flexible by compressing it to about 20 percent of its original thickness and then allowing to recover. Its main advantage is lightness and comparatively high allowable static loading. It is generally recommended to protect items having fragility factors in the range of 40 to 70 g but is not recommended for itmes having fragility factors in the range of 20 to 30 g. It is readily attacked by the fumes of solvents. It can be coloured if required as well as made fire retardent and is available both as slab stock and moulds.

6.2.5 *Rubber-Closed Cell Expanded Rubber* — This is a cellular rubber in which the cells are non-intercommunicating, made from masticated raw-rubber. Each grade of density has distinguishing colour. Normal grade contains little free sulphur. Sunlight affects cushioning property.

6.2.6 *Rubber-Open Cell*

6.2.6.1 *Sponge rubber* — Sponge rubber is cellular rubber in which the cells are all intercommunicating fully or partly. It is made from masticated raw rubber in a range of densities.

6.2.6.2 *Latex foam* — Latex foam is cellular rubber in which the cells are all intercommunicating fully or partly. It is made directly from liquid rubber latex in a range of densities. Both are useful commercial one-trip cushioning materials, but tend to age quickly.

6.2.7 *Sealed Air Cushions* — Sealed air cushions with different sizes of air pockets are available. These can be easily shaped and heat sealed for enclosing the products. They also provide protection from humidity.

6.2.8 *Felts*

6.2.8.1 *Pressed felts* — Pressed felt is made by closely felting or interlocking fibres to form a material of even texture and uniform composition without warp or weft. For more details *see* IS : 1719-1979*.

6.2.8.2 *Needle-loom felt* — Made by punching one or more layers of animal and/or vegetable fibres on to a woven base or interply, usually hessian. Both felts can give shock protection. Usual application is to prevent abrasive sensitive surfaces from becoming damaged by rubbing against the container.

6.2.9 *Springs and Shock Mounts* — Springs can be used either under tension or under compression. When used for suspension of an item, they will be under tension but when used as shock mounts they are under compression. Rubber patches are also used as shock mounts like springs. Their force replacement curves are linear and they behave as perfect elastic bodies, and hence, they rebound with all the energy by which, they are compressed and absorbed. Their natural frequency should be low so that they can isolate the vibrations.

6.3 Non-resilient Cushioning Materials — Non-resilient rigid cushioning materials are used for protecting packaged items from a single severe shock as is experienced in an airdropping. These materials absorb shock by the collapse of their structure and cannot return back to their original shape after the shock.

6.3.1 *Moulded Pulp Containers* — These types of containers can be defined as articles moulded from a mixture of water and any type of fibrous material capable of being treated by normal paper making processes. The raw material used can broadly be classified into the following two classes:

a) Moisture in varying proportions of virgin mechanical and chemical wood pulp either with or without the addition of waterproofing, hardening, colouring or other materials.

b) Waste paper pulps either with or without the addition of materials as above.

Pressure moulded containers are used in very large quantities for packing and projecting electrical and engineering components, for the protection of highly finished machine parts and for inter-departmental transit during manufacture.

*Specification for wool felt (pressed) (*second revision*).

6.3.2 *Polyurethane Foam (Right)* — This is formed by polymerisation and simultaneous expansion of an isocyanate and hydroxyl compound. Available in rigid sheets and moulding in a range of densities from 16 to 96 kg/m^3.

6.3.3 *Polyvinyl Chloride Foam* — This is an expanded thermoplastic material composed of vinyl chloride available in sheets in a range of densities from 32 to 64 kg/m^3. This is similar to expanded polystyrene (flexible) shape. When the material is used without pre-compression it acts as a non-resilient cushion if loaded sufficiently.

6.3.4 *Paper Honeycomb Structure* — A sheet material made of strips of paper bonded to each other such that when the end strips are pulled apart they form hexagonal cells at right angles to the direction of pull. Available in an infinite variety of paper and fibre board materials in a range of cell sizes from 6 mm onwards. Its main advantage is its exceptional lightness. It is widely used for parachute dropping.

7. TESTS

7.0 Compressibility and shock absorption are considered to be important characteristics for cushioning materials. Tests to determine these characteristics are described below.

7.1 Compressibility Test — A sample of the cushioning material shall be tested as described in Appendix B. The load required to compress the material up to one half of the volume shall not be more than 70 kgf and the residual compression of after removal of load shall not exceed 60 percent of total compression.

7.2 Shock Absorption Test — A cushioning material sample shall be tested as per the method given in Appendix C. The rebound shall not be more than 10 percent of the height of the drop.

APPENDIX A

(*Clause* 4.1)

COMPARISON OF PROPERTIES OF CUSHIONING MATERIALS

PROPERTIES	GROUND CORK	SAW DUST AND COIR PITH	PADDY STRAW AND DRY GRASS	WOOD WOOL
Hygroscopic	Yes	Yes	Yes	Yes
Water absorption	High	High	High	High
Corrosive effect	High	High	High	Low
Mould resistance	Low	Low	Low	Fair
Dusting	High	High	High	Fair
Temperature range	—	—	—	−10 to 45°C
Resistance against attack by	—	—	—	—
Susceptible to damage by	—	—	—	—
Resilience	Fair	Fair	Low	Low
Damping	High	High	High	Fair
Creep	—	—	—	Fair
Compression set	High	High	High	Fair
Density or grade	Low	Low	Low	960 kg/m³
Maximum deflection	—	—	—	50 percent
Peak load	—	—	—	241 kPa
Cushion factor	—	—	—	4·5
Form available	Granulated form	—	—	In loose or slab form
Used as	Space filler	Space filler	Space filler	Space filler
Load/deflection characteristic	—	—	—	Near linear

PROPERTIES	PAPER SHAVINGS	CELLULOSE WADDINGS	MOULDED PULP	CORRUGATED FIBRE BOARD
Hygroscopic	Yes	No	Yes	Yes
Water absorption	High	Low	High	High
Corrosive effect	High	Low	High	High
Mould resistance	Low	Fair	Low	Low
Dusting	Low	Nil	Low	Low
Temperature	—	—	—	—
Resistance against attack by	—	—	—	—
Susceptible to damage by	—	—	—	—
Resilience	Low	Fair	Low	Fair
Damping	High	Low	—	Low
Creep	—	—	—	—
Compression set	Fair	Low	—	Fair
Density or grade	Low	Low	—	—
Maximum deflection	—	—	—	—
Peak load	—	—	—	—
Cushion factor	—	—	—	—
Form available	—	—	Moulded form	In sheets, mould wrapper die cut pad
Used as	Against abrasion to mitigate shock precent reorientation	Surface protection dunnage	—	Wrapper, die cut pad
Load/deflection characteristic	—	—	—	—

PROPERTIES	FELT	PAPER HONEY-COMB	LATEX HAIR	RUBBERIZED COIR
Hygroscopic	Yes	Yes	Yes	Yes
Water absorption	High	High	Fair	Low
Corrosive effect	Can be made low	Can be made low	Low	Can be made low
Mould resistance	—	Low	Good	Good
Dusting	Low	Low	Low	Low
Temperature range	—	—	10 to 70°C	—
Resistance against attack by	—	—	—	—
Susceptible to damage by	—	—	—	—
Resilience	Low	Resilient up to crushing point	Good	Good
Damping	Fair	Low	Fair	Fair
Creep	Fair	—	Low	Low
Compression set	Fair	Low	Low	Low
Density or grade, kg/m^3	—	—	i) 64 ii) 96 iii) 144	
Maximum deflection, percent	— —	— —	i) 60 ii) 60 iii) 60 iv) 60 v) 60	
Peak load, kPa	—	—	i) 41 ii) 76 iii) 124 iv) 76 v) 76	
Cushion factor	—	—	i) 4 to 4·5 ii) 4 to 4·5 iii) 3·3 to 3·8 iv) 2·3 to 2·8 v) 3 to 3·3	
Form available	Rolls	In sheets	Die sheets	Sheets
Used as	Shock protection against abrasion	Non-resilient cushion	Resilient cushioning material	Resilient cushioning material
Load/deflection characterisitic	—	—	Tangent type	Tangent type

PROPERTIES	RUBBER CLOSED CELL EXPANDED RUBBER	RUBBER OPEN CELL	POLYURETHANE FOAM	EXPANDED POLYETHYLENE
Hygroscopic	No	No	No	No
Water absorption	Very low	High	High	Nil
Corrosive effect	Can be made low	Can be made low	Low	None
Mould resistance	Good	Good	Good	Excellent
Dusting	Low	Low	Low	Nil
Temperature range	−55 to +45°C	−40 to +45°C	−10 to +55°C	−20 to +70°C
Resistance against attack by	Alkalis, acids oxygenated solvent	Alkalis acids oxygenated solvent	—	Common acids, alkalis and solvents
Susceptible to damage by	Ultraviolet light aliphatic and aromatic hydrocarbons chlorinated solvent	Aliphatic aromatic hydrocarbons sunlight chlorinated	Ultraviolet light	Con. : HNO_3
Resilience	Good	Fair	Good	Fair
Damping	Fair	Low	Good	Good
Creep	Low	Low	Low	Low
Compression set	Fair	Low	Low	Fair
Density or grade, kg/m^3	i) 160 to 224 ii) 256 to 320 iii) 416 to 512	i) 400 to 480 ii) 240		i) 16 to 64 ii) 48 to 240
Maximum deflection, percent	i) 50 ii) 50 iii) 50	i) — ii) 60	i) 80 ii) —	60

PROPERTIES	RUBBER CLOSED CELL EXPANDED RUBBER	RUBBER OPEN CELL	POLYURETHANE FOAM	EXPANDED POLYETHYLENE
Peak load, kPa	i) 138 ii) 41 iii) 345	i) — ii) 103	352	248
Cushion factor	i) 3·5 to 4·5 ii) 3·5 to 4·5	i) — ii) 4 to 5	i) 1·9 to 3·0 ii) —	2 to 3
Form available	In sheet and moulded form	—	In slabs	In sheet form
Used as	Resilient cushioning materials	As resilient cushioning material	Resilient cushioning material	Resilient cushioning material
Load/deflection characteristic	Linear	Nearly	Anomalous	Anomalous

Properties	Expanded Polystyrene	Rubber Shock Mounts	Metal Shock Mounts
Hygroscopic	No	No	No
Water absorption	Very low	Very low	Nil
Corrosive effect	Low	Can be low	—
Mould resistance	Good	Good	Excellent
Dusting	Low	Nil	Nil
Temperature range	−200 to +70°C	−40 to +70°C	−60 to +100°C
Resistance against attack by	Dil. acids and Con. alkalis	—	—
Susceptible to damage by	Aromatic, aliphatic and chlorinated hydrocarbons	—	—
Resilience	Fair	High	Good
Damping	Good	Can be high	Can be added
Creep	Low	Low	Nil
Compression set	Fair	Low	Very low
Density	16 to 112 kg/m^3	—	—
Deflection	60 percent	Up to 100 percent	50 to 80 percent
Peak load	483 kPa	—	Varies
Cushioning factor	3·5 to 5·0	2 to 5	2 to 5
Form available	In slab and mouldings	—	—
Used as	Resilient, space filler, non-resilient	Resilient	Resilient
Load/deflection characteristic	Anomalous	Bi-linear	Varies

APPENDIX B

(*Clause* 7.1)

COMPRESSIBILITY TEST

B-1. PROCEDURE

B-1.1 A sample of the material shall be taken and conditioned at 65 ± 5 percent R.H. and 27 ± 2°C temperature. The conditioned sample shall be filled in a frame of 200 mm × 200 mm × 100 mm in size in a manner as to simulate the general compactness in packaging. The frame shall be kept on the platform of a universal testing machine. A rigid plate of 195 mm × 195 mm in cross-section shall be placed over the material. The load shall be applied by means of hemi-spherical loading block of radius 50 mm at the centre of the plate with a continuous and uniform rate of motion of moving head equal to 2 mm/min and compression shall be noted correct to 0·1 mm by means of a scale fixed on the loading block. The test shall be continued till 50 mm compression (that is, material is compressed to half of its volume) is reached. For this compression the required load shall be recorded. The load shall then be removed and the residual compression shall also be recorded.

B-2. The load required to compress the material to half of its volume and residual compression immediately after the removal of the load shall comply with the requirements of **7.1**.

APPENDIX C

(*Clause* 7.2)

C-1. PROCEDURE

C-1.1 A sample of the material shall be taken and conditioned at 65 ± 5 percent relative humidity and 27 ± 2°C temperature. The conditioned sample shall be completely and uniformly filled in a frame of 200 mm × 200 mm × 100 mm in size and a rigid plate of 195 mm × 195 mm in cross-section shall be kept over the material. A cubical block of 100 mm × 100 mm × 100 mm shall be fixed on one end of a rod. The rod shall be square in cross-section and graduated in centimetres. The total mass of the block with rod shall be 1 kg. The cubical block with rod shall be dropped 10 times on the centre of the plate from a height of 75 cm with the help of suitable guides. The rebound of the rod shall be read at any convenient horizontal position by means of the guide at each drop.

C-1.2 The rebound shall not be more than 75 mm (that is, 10 percent of the height of drop) in all the 10 drops.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

QUANTITY	UNIT	SYMBOL
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

QUANTITY	UNIT	SYMBOL
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

QUANTITY	UNIT	SYMBOL	DEFINITION
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2